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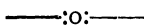
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is different from that here presented, and embraces a different series of observations.

The lack of agricultural museums in which domesticated varieties of plants find representation, the general ignorance of the varieties which were grown by our predecessors, and the in general careless descriptions which occur in the writings on agriculture, render a study of this sort embarrassing and difficult. A careful study, however, of the figures given by the botanists of the sixteenth century and thereafter, and a careful collation of evidence gleaned from more recent authors on gardening, together with the fact that the appearance of new form-species of cultivated vegetables seems to date from the introduction of forms of the same species from distant regions, and the rarity of appearance of novelties which cannot be identified with some previously described type,<sup>1</sup> all encourage to the belief in the correctness of the generalization that in our domesticated vegetable plants cross-fertilization shows its effect at once in the reproduction of the form-species and varieties which are involved in the parentage of the crossed seed, and that when "pure seed" is crossed intermediate forms rarely occur, but the original parents in variable proportions.



## OBSERVATIONS ON THE MUSKRAT.<sup>2</sup>

BY AMOS W. BUTLER.

THE muskrat (*Fiber zibethicus* Cuv.) is very abundant in most localities in Southeastern Indiana. In local distribution it varies in numbers according to the abundance of water and favorable localities for its increase. From all that I can learn, I do not think it is less common than at the time of the early settlement of this region.

These animals soon became acquainted with man and, from experience, learned that his presence assured them a great abundance of food at much less labor than formerly, while, at the same time, their natural enemies decreased in numbers on account of his necessity and pleasure. In some localities, owing to the perse-

<sup>1</sup>For instance, the deer tongue lettuce, with lanceolate leaves, which appeared about 1883, is almost identical with the *Lactuca folio oblongo acuto* figured in Bauhin's *Prodromas*, edition of 1671, p. 60.

<sup>2</sup>Read before the section of Biology of the American Association for the Advancement of Science at Ann Arbor, Mich., Aug. 27, 1885.

cution of a neighborhood of farmers, muskrats are few in numbers and are very shy. In the greater number of places, however, but little attention is paid to their destruction, and in consequence they become very tame, being found within the corporate limits of some of our larger towns. Originally they had their home in the neighborhood of natural water-courses, but with the system of State improvements which led to the building of our canals, there came, in many localities, a change in the life of the muskrats. Upon the completion of "The White Water Valley Canal," in 1846, the greater number of muskrats living upon the streams along which it ran, sought this artificial water-way and there established homes. No doubt they soon realized the greater security this canal afforded them from the frequent floods and from other dangers they had formerly experienced. At the present time, along that portion of the canal in existence, but few muskrats have sought the neighboring streams whence their ancestors came. When the muskrats changed their residence to the line of the canal they made new homes in its loamy banks, similar to the ones they had deserted along the river side. They are found both in our water-power canal and in the swifter streams, most numerous where there is a good food supply and at the same time near by a quiet nook secluded from the prying eyes of some human enemy and his allies. I have noticed them to be exceedingly abundant about the estuaries of creeks whose banks are covered with a luxuriant growth of vegetation.

When the canal through this part of the State was destroyed in 1866, the rats disappeared from many places where they had long found a home. Some sought the river where their ancestors had dug their holes in times long past; others gathered into certain parts of the old canal bed which were not permitted to remain unused. One of these portions is now the property of "The Brookville and Metamora Hydraulic Company," and is used for the purpose of supplying power to several mills along its banks. This part of the old canal is about fifteen miles long, extending from Laurel to Brookville. It is here that I have become best acquainted with this water-loving rodent.

The muskrat prefers its home in banks of loam or light clay, especially when heavily covered by vegetation. It is very exceptional that it occupies gravelly or sandy banks. Advantage has been taken of this fact by the managers of our water-way and

by the railroad company. Where they have constructed gravel banks and kept them free from vegetable growth, it is rarely they are bothered. Trenching the banks and filling in the trenches with gravel has proved of considerable value, while some protection has been afforded by a top-dressing of coarse gravel over an old bank of loam, provided vegetation is not allowed to grow thereon. When these precautions have not been taken, great damage is done each year; the burrows of these animals are continually being enlarged, and caving in, cause a leak, or undermine the railroad track, as the case may be.

In early spring the greatest damage is done. With the alternate freezing and thawing at that time of the year, the coverings of these underground passages drop in, exposing cavities of surprising extent to one who does not know the amount of subterranean work this animal is capable of doing. It requires vigilant work of eyes and ears to prevent this caving causing great damage to property. The underground homes of the muskrat in the banks of the canal have each two openings. When the water is at its usual stage an opening may be found, the upper edge of which is on a level with the surface of the water; another hole may be seen at low-water mark, the top of which is just level with the surface of the water at that stage. These holes are generally from eighteen inches to two feet apart. The passages from these openings lead backward and upward in a very crooked way, as any one who has attempted to follow them up can testify. These passages end in a large gallery which is the home of the animal. From this chamber a small passage leads to the surface, ending amid a bunch of grass or weeds. By this means the gallery is ventilated. The holes at the surface are known as "air holes." They are not always found, at least I have not in all instances observed them. In heavy ground an "air hole" is always found, while in porous ground it is as often absent as not. These underground burrows extend into the bank a distance of ten to twenty feet in a straight line, as a rule. Instances have been noted where the depth reached was less than the minimum given above, but such are rare. In localities along small streams which are subject to sudden rises, the distance attained occasionally reaches thirty feet, but in all instances the depth to which these burrows reach depends, in a great measure, upon the size and composition of a bank as well as upon the liability of the neighboring stream to sudden changes of level.

In the abandoned parts of the old canal before referred to, the muskrat built houses for the first time in this part of the State. They were few in number, and were confined to wet tracts, the source of whose water supply was springs from the neighboring Silurian hills, or in swamps adjacent to the line of the canal. Until within the past three years no houses had been built along the water-power canal between Brookville and Laurel. Each succeeding year I noticed the erection of a few more houses, until at this time there are a dozen or more within the fifteen miles just mentioned. Within ten miles of the northern end of this artificial water-way, in the old bed of the canal, have been several houses for a number of years. Whether this house-building habit is caused by some of the house-building muskrats coming from up the stream, or whether, from some unknown reason, the animals of our own locality have thus taken upon themselves this much of the ways of some distant ancestor, we cannot say. That muskrats do, from force of circumstances, change their location, is a well-known fact, and such a change would perhaps be the most logical way to account for the recent house-building just mentioned.

I have made careful examination of some of these houses, and herewith present some extracts from my notes on one of them which I consider typical in construction and arrangement. The examination of this house was made in January last when the ground was frozen, but the more rapid streams had little or no ice upon them. This particular house was built upon the highest part of a piece of marshy ground on a peninsula extending into a stream which passed through the marsh. The end of the peninsula had been dug off to the level of the bottom of the stream, leaving a semicircular exposure of land. A part of the base of the house followed the configuration of the edge of this excavation, while the remainder of the foundation rested upon the bottom of the stream. In consequence of this rather more than half of the house adjoined the water. The house was composed chiefly of swamp grass, sedge, coarse weeds and mud, while fresh-water algæ, small pieces of drift, a few pieces of shingles and two staves were found among the more common material. The greater part of the mud was in the lower part of the house, and I think was mostly brought in attached to the roots of grass. The ground in the neighborhood of this house was cleared of all

vegetation, even of the roots, for some distance. The house was thatched very nicely with weeds and sedge. The ground plan was oval in outline, four feet six inches wide and six feet three inches long. On the land side the house was two feet six inches high, and on the water side three feet four inches. The whole presented the appearance, in miniature, of an oblong hay rick. The inside was quite irregular. Measurements at the bottom of the chamber showed the greatest length to be twenty-two inches, the least sixteen inches, with an average width of twelve inches. The greatest height, measuring from the bottom of the stream, was one foot. Six inches from the bottom a shelf was found running from the left of the entrance and above the top of the water. This shelf was twelve inches long and eight inches wide, and ranged from six to eight inches in height. It was arched over very neatly with drift and coarse weeds. At a point farthest from the center of the chamber, immediately over the shelf, was a passage leading upwards toward the side of the house. While it did not penetrate the wall, it passed through the more compact portion and enabled the inmates to obtain air. Entrance was had through a covered way from and beneath the water without to the center of the house, where it terminated in a mass of fine grass and mud, through which was a funnel-shaped opening to the interior. This house was completely destroyed; within a week after its destruction the muskrats had erected a new home upon the site of the old one. In securing material for this they had used the remains of the ruined house, and had cleared a much larger space of ground of its withered vegetation. In outline the new house resembled the old one very much, but it was of nearly double the size of the ruined structure. There are peculiarities in the shape of many houses, but that which I have described appears typical in form and in interior arrangement of these structures in this vicinity. Some of these houses are built at a time when the water is low, and as the fall rains swell the streams the rats are compelled to reconstruct their buildings, raising the top above the highest level of the water. I knew a muskrat to try this plan last year. It built its house within the banks of an ice-pond which was almost dry; as the water was turned on, late in the fall, the owner tried, by making the house higher, to keep a portion of the structure above the encroaching water. An increase in altitude of six feet was too much for the

industrious animal ; by the time half this height was reached he gave up the work. Occasionally instead of laying a part of the foundation out of the water, the house is begun entirely within the water. At times I have known a hollow stump, which had a lower opening beneath the water, to be used. The stump being covered over and some grass and other material placed around the base, it required close observation to recognize the framework of the structure. I have known these animals to take possession of a barrel which stood on its end in the water, and after covering it over so as to almost hide it, to give up the work and erect a dwelling without the substantial assistance such an article would afford.

I find the muskrat lives, the greater part of the year, in its sinuous galleries in the banks of our streams. Each autumn new houses are built or old ones repaired, but these are only occupied when the surrounding streams are locked in a sheet of ice. At such times it is by no means uncommon to find several representatives of the species living in harmony within one of these winter homes. I am convinced that in this vicinity one brood of muskrats is regularly brought forth each year. There are, in all probability, occasional exceptions to this rule, when perhaps two and even three broods are born. Mating takes place late in February or early in March, depending upon the condition of the weather, and continues about three weeks. This year these animals were first noted as mating on March 10th. At this season the female utters a hoarse squeal by which the males are attracted. The period of gestation is about six weeks. In April or early May the young are brought forth ; from four to six helpless and hairless little creatures may then be found by the persevering investigator far within the subterranean home within a nest of grass and other soft vegetable growth. The young remain in the nest until they are about half grown, unless their home be flooded, when they often perish, but in some instances are rescued by the mother. Mr. E. R. Quick relates one instance when, during a flood July 3d, 1873, he saw a female muskrat swimming along in the muddy water with five young, about the size of a full-grown house rat, holding on to tufts of the mother's hair with their mouths, while she made her way slowly and cautiously along the shore ; carefully she avoided all obstructions and swift water, seeking a shelter for her precious tow. Some boyish enemy, per-

ceiving the homeless family, threw a stone which struck the mother and scattered the young. The latter apparently knew nothing of diving and but little of swimming; with difficulty they gained the shore, and while seeking the protection of some reeds a part of them were caught. I have never found the young caring for themselves until after the beginning of July. In September, a few years since, a litter of young was taken from a nest in the canal bank. They were not over one-third grown. This record I have always considered as referring to a second or perhaps a third brood, and is my only note that would indicate a plurality of broods.

During the rutting season the grunts of the males answer the squealing of the females, the noise of scuffles between the males, the continuous splashing made by the animals in the water fill the air, in the vicinity of one of their favorite ponds, with sounds which would surprise one who was not familiar with the neighborhood of a muskrat's home, on a warm night in early spring. At this time of the year they are seen during daylight more than at any other, sometimes even deigning to show their love-making to inquiring eyes.

Musk rats are naturally herbivorous. They feed upon land and water plants alike, in some instances using roots, stems and fruit. They are noted enemies of the "bottom" farmer. In his fields it is that corn grows most plentifully, and upon this cereal muskrats love to feed. They eat corn at any time after it is planted, taking the seed from the ground or the young plant from the furrow. The greatest damage is done after the ear is well formed. "Roasting ears" appear to be a favorite article of food with them. From this time until the corn is gathered, nightly visits are made to the neighboring cornfield, where the stalks are cut down and sometimes carried to their homes, but more frequently the juicy ear is the only part taken. At times streams near cornfields seem covered with floating stalks, the result of the muskrat's nocturnal forays. As the corn becomes hard it is frequently a difficult question for them to tell how they will get the grains off the cob as easily as formerly. They evidently master the question in some instances, for I have known them to deposit the flinty ears in a stream for two or three days until the grains become soft, when they could be readily removed. It seems strange that an animal having teeth of the cutting power those of the muskrat possess,



should seek to do this, but in all probability the teeth, from continued eating of vegetable food throughout the summer, become tender and are unable to cut hard grains of corn with ease. This is the case with many domestic animals in autumn when fed on corn after some months of pasture life. Muskrats are very fond of parsnips, turnips and apples. They frequent apple orchards and turnip patches, near their homes, and make use of much of the farmer's abundant crop of these articles. When snow, which had lain on the ground for some time, melted, I have observed that plats of grass near the water's edge had been eaten bare by these animals while they were confined to such diet as they could find beneath the ice. Their food is not entirely vegetable; in winter and in early spring they subsist, in a great part, upon the flesh of river mussels. Many a winter morning have I found a number of well cleaned shells of the more delicate mussels upon the ice near swift, running water. I have never been able to satisfy myself that this food was used by them at any other time of the year. Neither do I believe that this material was originally so used. It is very probable that owing to the scarcity of suitable vegetable food, they have been forced to include the meat of the mussel among their articles of diet; largely on account of its abundance near their watery haunts and also on account of the ease with which it is obtained. Such change of food has not occurred in this region within historic time, perhaps, but it is evident that formerly, when there were few mussels in these rivers, not so many of them were eaten. With the conditions favorable to their development produced by our canal, mussels multiplied very rapidly, and in proportion to their increase in numbers the muskrat increased his mussel-eating. Records of this are preserved in the banks of the canal; alternate deposits of shells, cleaned by the muskrat, and of sediment may be seen in many localities reaching to the depth of two feet below the present bed of the stream. Upon these same piles of bivalve remains the muskrat leaves the remains of most of the mussels it eats. I have never known the muskrat to eat univalve mollusks. I have identified the following shells as forming the principal part of its bivalve food in this vicinity: *Anodonta plana* Lea, *A. decora* Lea, *A. imbecillus* Say, *Unio luteolus* Lam., *U. parvus* Barnes, *Margaritana rugosa* Lea, and *M. complanata* Lea; all common in proportion to their comparative abundance. In some localities I

found the young of *Unio occidentalis* Lea, but not very common. In another locality where *Unio lachrymosus* Lea is the prevailing species, I found its shells forming the bulk of the refuse near muskrat homes. In this same locality I found examples of *Unio plicatus* LeS. and *U. multiplicatus* Lea, but they were not common. The young of heavier shells are to be found as commonly, in proportion to their abundance in the adjacent water, as are the remains of the more fragile species. I have estimated that about one-half the mollusks eaten are of the three species of Anodonta. I was surprised at the comparative abundance of the remains of *Margaritana rugosa* Lea in these piles of shells. This species is considered to be rather rare, but their shells are found as frequently there as are those of some of our more common species. From this fact I think the muskrat prefers the flesh of this species to that of others which might be more easily taken. I have, at times, found examples of living Unios among these heaps of shells; whether these had been brought there by the rats, or whether they had sought, of their own accord, a dwelling place among the remains of their dead ancestors I cannot say. The means by which the muskrat secures the body of a mussel has been frequently discussed of late. I think, from my observations, there are three ways in which these shells are opened. With many species I notice that the foot is very slowly withdrawn within the covering when the shell is handled. When such shells are taken it is very easy for the muskrat to insert its paws or long teeth between the valves and tear them asunder. The remains of some species show evidence of the cutting power of their enemy's teeth, the edges are broken; when this is done it would be very easy for the muskrat to find a sufficient opening to secure the animal as in the preceding instance. By those two ways the more fragile shells may be opened; the heavier species which are occasionally found, nicely cleaned, about the opening of the muskrat's home, could not be opened in this manner. I have on several occasions noticed these larger mussels lying on the bank of a stream near a muskrat hole, and within a few days they disappeared. The only way in which I can see the muskrat could obtain the body of one of these larger mollusks is by leaving the animal out of the water until it becomes weak or until it dies, when the valves could be easily separated. Muskrats at times eat of the bodies of dead animals. The remains of ducks, geese,

chickens, fish, and even in one instance a turtle, have been noted as forming a part of their food. The farmers of the lowlands ascribe to the muskrat a love for young ducks, but I think the greater part of their loss in this particular is referable to turtles.

The muskrat is largely nocturnal in its habits. On cloudy days and occasionally late in the afternoon one may be seen, along some quiet stretch of water, seeking food or looking for its mate. It is not much at ease on land, although when pursued it moves over the ground at an ambling gait with some degree of rapidity. It is an expert at swimming and diving. Before diving it appears to inflate its lungs with air, and when it disappears remains beneath the water for some time, the course it takes being frequently traceable by rising bubbles of air. When surprised it plunges into the water suddenly without the necessary supply of air, and is forced to come to the surface in a very short time. When frightened it generally seeks its hole, but such is not always the case. In open water it dives to a considerable depth, and I have noticed it passing through shallow water apparently running upon the bottom. Under the ice it may be noticed, at times, swimming quite close to the surface of the water. It appears disinclined to dive in muddy water. Upon several occasions, when our streams have been swollen, I have attempted to make one dive by stoning it, but generally without success; sometimes it would dive, but would almost immediately reappear. When our water-courses are covered with ice the muskrat has regular places of egress and ingress, such places being where, owing to swift water, ice had not formed, or where the ice along the banks of a stream had become broken.

Several methods are employed to capture or to kill muskrats. Many of them are caught by means of steel traps. They are very unsuspicious and regularly become the victims of their self-assurance. A dead fall is frequently used with some effect. It is generally placed over a well-worn runway leading to a favorite feeding ground. Many muskrats are killed by means of poisoned apples or turnips which are placed in the neighborhood of their burrows. The latter plan is often tried by the farmers of our uplands to kill these animals when they become too numerous in the ditches and smaller streams. A method used with great success by a local water-power company, in winter, is as follows: A barrel with both ends out is placed upright near the bank with

about half its length in the water. Upon the water inside the barrel is placed grass and weeds, and on this foundation the bait, generally a few pieces of parsnip, is put. In a few days the animals will become familiar with this new object, and thereafter the barrel may be visited regularly. After a warm night the trapper is reasonably sure of finding some game in his barrel. Sometimes he will find but one or two rats, but more frequently he will catch from three to six, and on one occasion I have known ten rats to be taken in one barrel in a single night. At mating time if a female be caught several males will be taken prisoners in the same barrel in their efforts to become her company. When a rat gets into the barrel it is impossible, owing to the depth of the water, for it to stand upon its hinder limbs to cut a hole in the staves above water line, and at the same time impossible for it to get out at the top of the barrel. When several are taken the same night a fight generally ensues, resulting in the death of all of the captives either by the sharp teeth of their companions or by drowning. I have known instances where several of these rats had been captured and killed, but the trapper did not visit his traps for some time; upon his arrival, however, he found but a few heads and bones to tell of the tragedy that had been enacted and of the feast which the other muskrats had when the water receded enough for them to enter and leave the barrel. This habit is not uncommon when more acceptable food is scarce. Last spring a muskrat was caught in a steel trap; when the trapper went to his trap next morning he found another rat eating the dead one; upon examination it was found the entire right shoulder had been eaten off. Spears are rarely used, but they are sometimes brought into service when the streams are ice bound to kill the inhabitants of a winter house. Many muskrats are shot in early spring when the ice breaks up.

Of the enemies of the muskrat man ranks first, and next to him the dog. Hawks and owls of the larger species, foxes and minks are all very destructive to this animal. The mink is perhaps its greatest natural enemy, but fortunately for it minks are rare. The remains of muskrats have, on several occasions, been found in the stomachs of large catfish, but the flavor of the food had been so thoroughly imparted to the meat of the fish that it was unfit to eat. The muskrat is at times very ferocious. When cornered by dogs or man it frequently shows fight, and if pressed too closely is able to do much execution with its sharp teeth.

Muskrats have their pleasures as do other animals, but as their favorite time for sport is after night, we have but little opportunity to become acquainted with them socially. On a warm quiet afternoon they appear to enjoy a sunning in some secluded spot. Their gambols in the water, of a quiet evening, remind me much of the playing of kittens. They may be seen at times, of a moonlight night, chasing each other over some sand bar near their watery home. On the whole a study of their enjoyments is very unsatisfactory, and much of our knowledge of the life history of these animals will be but slowly acquired.

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## THE PROBLEM OF THE SOARING BIRD.

BY I. LANCASTER.

IT is now more than two years since I first made known the results of investigations on the methods of flight of the great soaring birds, carried on at intervals since 1850. The whooping cranes of the Northwest, performing their migrations on motionless wings, had at that early date fixed my attention, and my times of leisure down to 1876 were devoted to ransacking the scientific and literary world and to observing the birds in the act whenever it was possible to do so, that I might get an explanation of the phenomenon of more substantial character than mere guess-work. Plenty of assumed solutions were found scattered about. Such theologians as I consulted were confident that the question had reached its lowest terms when it was said that "God had created the birds to fly." Common-sense folks rejected the idea of fixed wings and held to a slow flapping that could not be seen, while the scientists were confident of upward slanting currents of air and various atmospheric disturbances which produced the result. Accounts of travelers as to the facts were hopelessly confused, with a single exception, that of Charles Darwin in his *Naturalist's Voyage around the World*. His solution of the matter, that of the surging head, was given provisionally.

I was not prepared to deny any of the solutions given and not more ready to admit them, being conscious of very much ignorance of the entire matter. Meanwhile my interest in the subject, constantly increasing, had, in 1876, overshadowed all others, and being disengaged from business, I devoted the ensuing five